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AN EVALUATION OF 9 EAST'S MONOLITHIC PACKING AS A GOB SEALANT

A.W. Stokes
Cape Breton Coal Research Laboratory

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AN EVALUATION OF 9 EAST'S MONOLITHIC PACKING AS A GOB SEALANT

by

A.W. Stokes*

SUMMARY

The Cape Breton Coal Research Laboratory has been involved in evaluating the effectiveness of gateside packing systems for reducing air leakage through longwall wastes. A monolithic packing system has been in use on 9 East longwall in CBDC's Lingan Colliery for almost one year with a total length in excess of 700 m now in place. A recent survey has shown that the monolithic packing does reduce the air leakage and could allow a 2500 m longwall to be completed without utilising cundy ventilation. This report describes the results of that survey and compares them with similar readings from 8 East and 4 West. Computer predictions have been made to estimate the increased load on the mine's ventilation system that will result if monolithic packing is used on future longwall faces.

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*Research Scientist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

ÉVALUATION DU REMBLAYAGE MONOLITHIQUE EN TANT QU'AGENT D'ÉTANCHÉITÉ POUR LES FUITES DANS LES REMBLAIS DE LA SECTION 9 EST

par

A.W. Stokes*

RÉSUMÉ

Le Laboratoire de recherche sur le charbon du Cap-Breton a entrepris d'évaluer l'efficacité des systèmes de remblayage monolithique de réduire les fuites d'air dans les remblais d'une zone exploitée par longue taille. Depuis un an environ, un système de remblayage monolithique est utilisé dans la galerie de longue taille 9 Est de la mine Lingan (SDCB) où il y a actuellement 700 m de remblai en place. Les résultats d'une étude récente ont démontré que le remblayage monolithique réduit les fuites d'air et permettrait une exploitation par longue taille de 2 500 m sans avoir recours au mode de ventilation "cundi". Ce rapport décrit les résultats de cette étude et les compare avec les résultats obtenus lors d'une étude semblable effectuée dans les sections 8 Est et 4 Ouest de la mine. Des valeurs théoriques calculées à l'aide d'un ordinateur ont été préparées afin d'évaluer l'effet qu'aurait une augmentation de la charge de ventilation sur le système de ventilation, causée par l'utilisation du système de remblayage monolithique dans les futurs travaux d'exploitation par longue taille.

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*Chercheur scientifique, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources Canada, Sydney.

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INTRODUCTION

The Cape Breton Coal Research Laboratory has been working for the past eighteen months to assess the performance of different gateside packs for reducing air leakage through the caved wastes of advancing longwalls. The investigations have centred on the support characteristics afforded by the new packs and the effect on the ventilation. Previous reports describe in detail the investigative methodologies and the preliminary results (1,2, 3,4).

The packing system on the intake gateroad of 9 East longwall in Lingan Colliery was changed from conventional wooden cribs to a monolithic pack (Astrapack) in March 1985; at this time the face was 640 m in. Since then frequent measurements of the air leakage have been made and these have become more accurate and reliable as the length of monolithic pack has increased. The adjacent longwall, 8 East, is scheduled to finish in February 1986, at which time a short roadway will be driven from it to intersect the return gateroad of 9 East close to the face. This will allow cundy ventilation to be used to reduce the leakage in 9 East (5). The use of cundy ventilation will effectively prevent the continued ventilation monitoring of the monolithic packing due to the change in the airflow distribution in 9 East. Therefore a final leakage survey of 9 East was conducted in January 1986 when the longwall face had advanced to 1375 m in with over 700 m of monolithic packing in place.

This report describes the results of the January 1986 survey and compares them with similar surveys conducted on 8 East and 4 West. A series of graphs show the increase in gob resistance produced by the monolithic packing for a range of gob flow regimes (e.g. fully tubulent through to laminar).

The resistance values obtained for the last 9 East survey were used to develop a computer model to simulate the effect of using monolithic packing from the face startline to the completion of a 2600 m longwall. From these predictions an estimation of the additional load on the mine ventilation system is given.

CONDITIONS IN 9 EAST

Two ventilation surveys were conducted in January 1986 on the 18th and 26th. At this time 9 East had advanced 1375 m in from the face startline with monolithic packing along the bottom level from 640 m in up to the faceline.

The top level gateside pack had been changed from three parallel lines of stone filled wooden chocks to a single line of hollow wooden chocks approximately 150 m back from the face.

METHODOLOGY

The techniques used in these surveys were identical to those used previously which are documented in more detail elsewhere (4). Briefly, sulphur hexafluoride (SF_6) was used to measure airflows at a number of measuring stations along the tailgate. From these measurements the air leakage through the gob was calculated. The differential pressure across the gob was determined from a gauge and tube survey around the district. The air leakage and differential pressure profiles were used to determine the resistance of the gob, and these values were used with the roadway and face resistances to create a ventilation network analysis model with which district ventilation predictions were made.

RESULTS

GATEROAD AIRFLOW PROFILE AND DIFFERENTIAL PRESSURE PROFILE

Figure 1 shows the airflow profile measured along the 9 East tailgate and (using the same x axis) the differential pressure profile around the district.

GOB CORRIDOR RESISTANCES

Figure 2 shows the resistance of the gob corridors in 9 East as calculated from the results in Figure 1 and assuming fully developed turbulent flow in the gob.

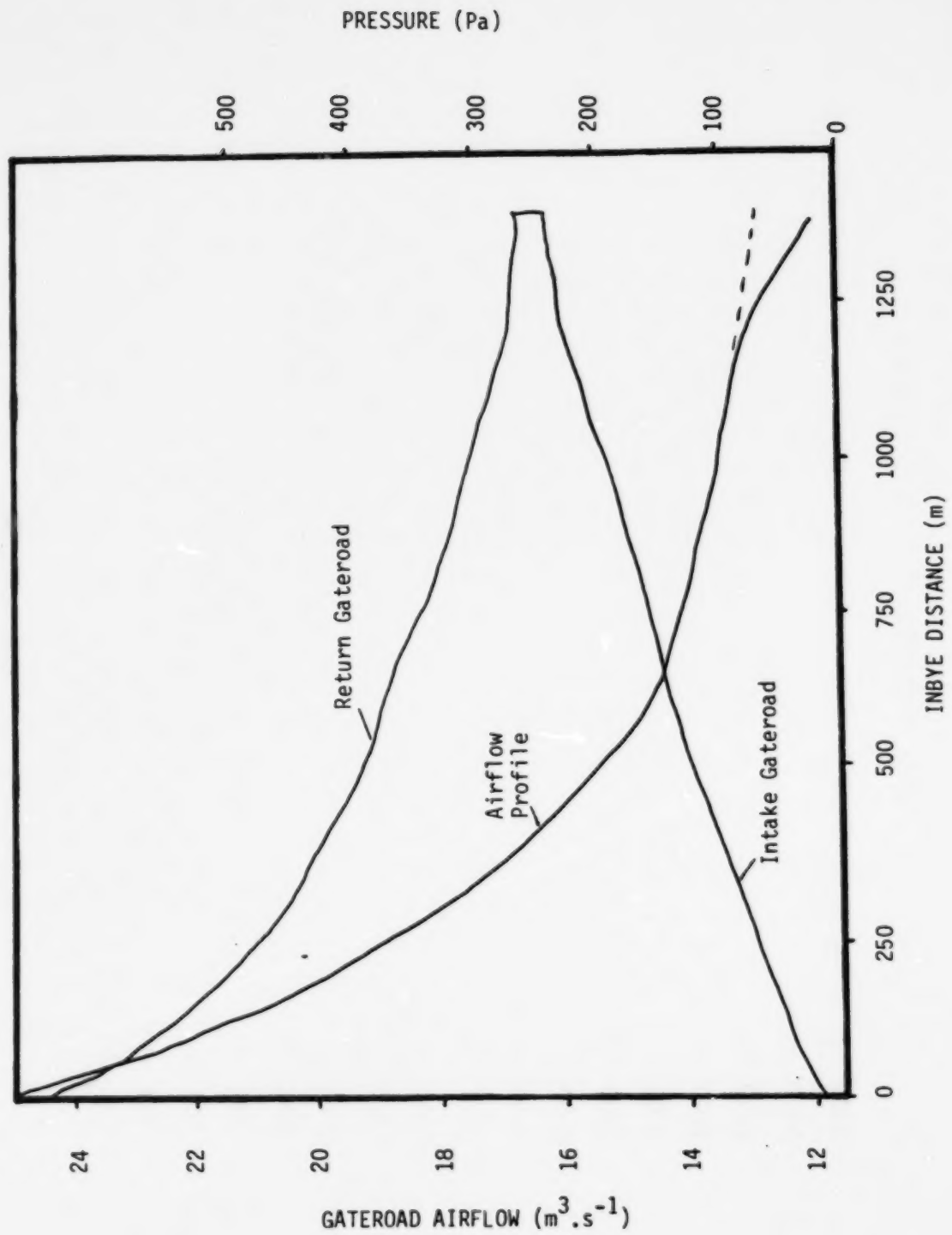

Figure 1 - 9 East airflow and differential pressure profiles

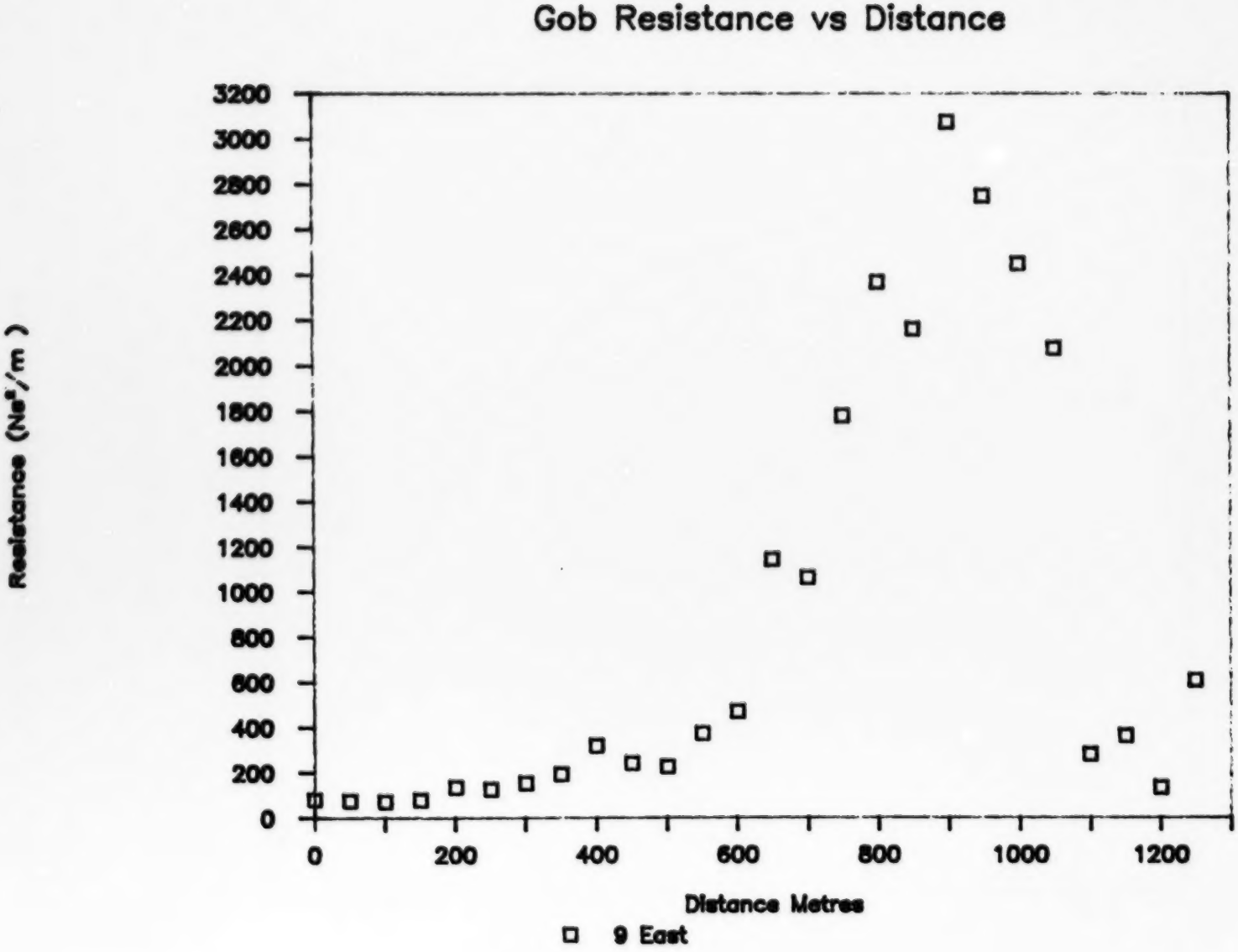

Figure 2 - 9 East gob corridor resistances

COMPARISON OF 4 WEST, 8 EAST AND 9 EAST GOB RESISTANCES

Figure 3 shows the gob corridor resistances for 4 West, 8 East and 9 East based on fully developed turbulent flow in the gob. Figure 4 is the same gob corridor resistances calculated assuming laminar flow in the gob and Figures 5 to 7 show the same resistances assuming flow regimes between laminar and turbulent

DISCUSSION

The tailgate airflow profile and the differential pressure profile are similar to those recorded in previous surveys. The only noticeable difference is a drop in the airflow profile in the 150 m of roadway immediately behind the face. Air movements in this area of the gob are known to be varied due to the proximity of the face and it is likely that this drop was caused by air leaving the face and short circuiting the return face end rather than a leakage directly from the intake. There are two reasons to support this supposition. Firstly, sandstone channels had been intersected near this area which could have been preventing complete caving of the gob. Secondly, the gobside packing system in the return has been changed from a series of solid stone filled packs to a more porous line of hollow wooden packs. The length of this new pack now in place is about 150 m. Both of these factors could be causing a reduction in the gob resistance in the top corner behind the face; thus promoting leakage from the face to the return.

If then this lowering of the profile is due to conditions of the return side of the gob, then ventilation efficiency along the intake side is probably better. A dotted line has been drawn in on the airflow profile to compensate for this. Assuming then that this was correct, the ventilation efficiency of 9 East longwall is over 40 percent. This represents a considerable improvement over the predicted efficiency for a conventionally wooden packed east side longwall of the same length (less than 30 percent).

The 9 East gob corridor resistances were calculated from the January 26 survey results. A graph of these is shown in Figure 3 (calculated assuming turbulent flow relationship). A large increase in the resistances

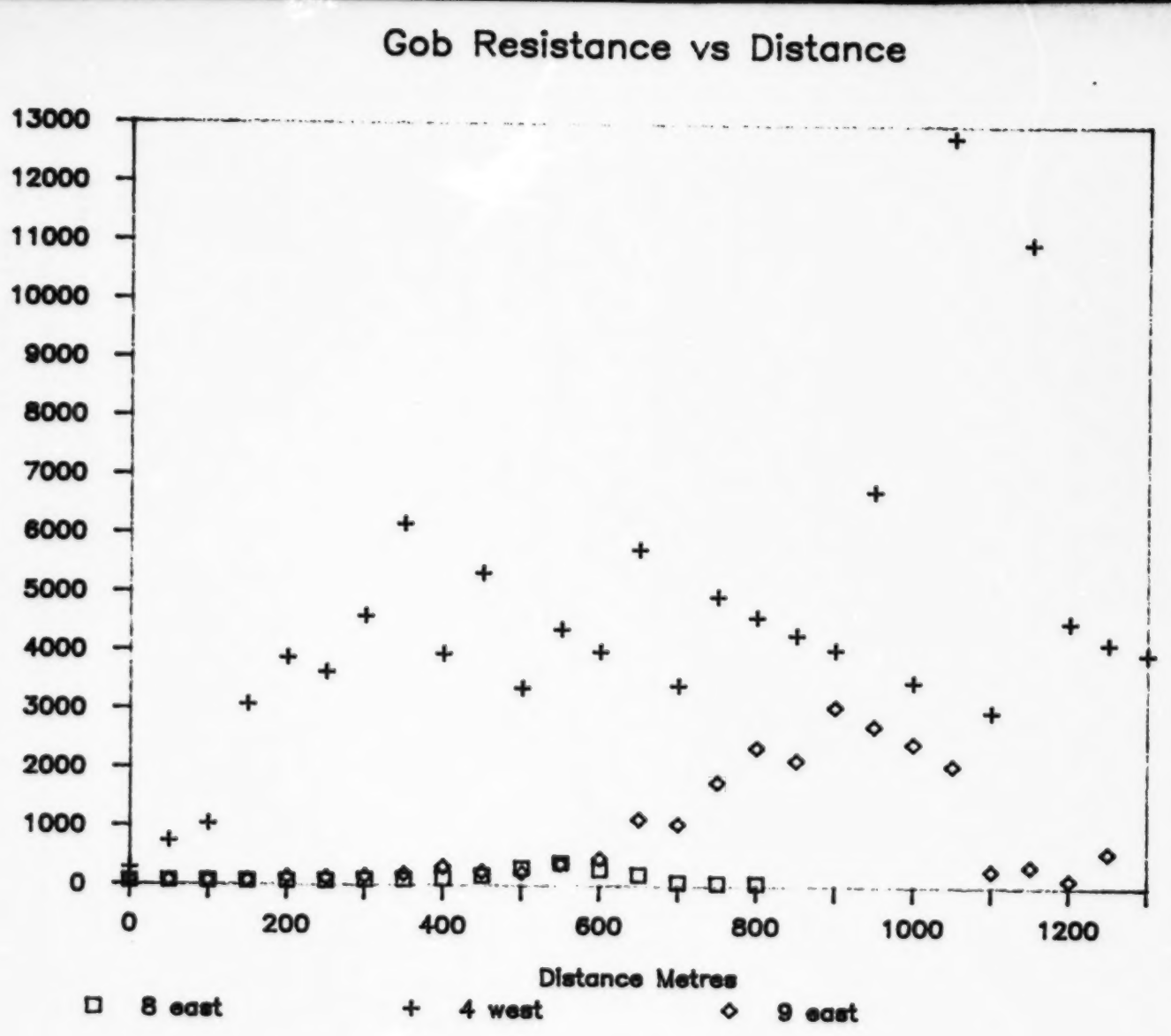

Figure 3 - Comparison of gob resistances assuming turbulent flow (n = 2)

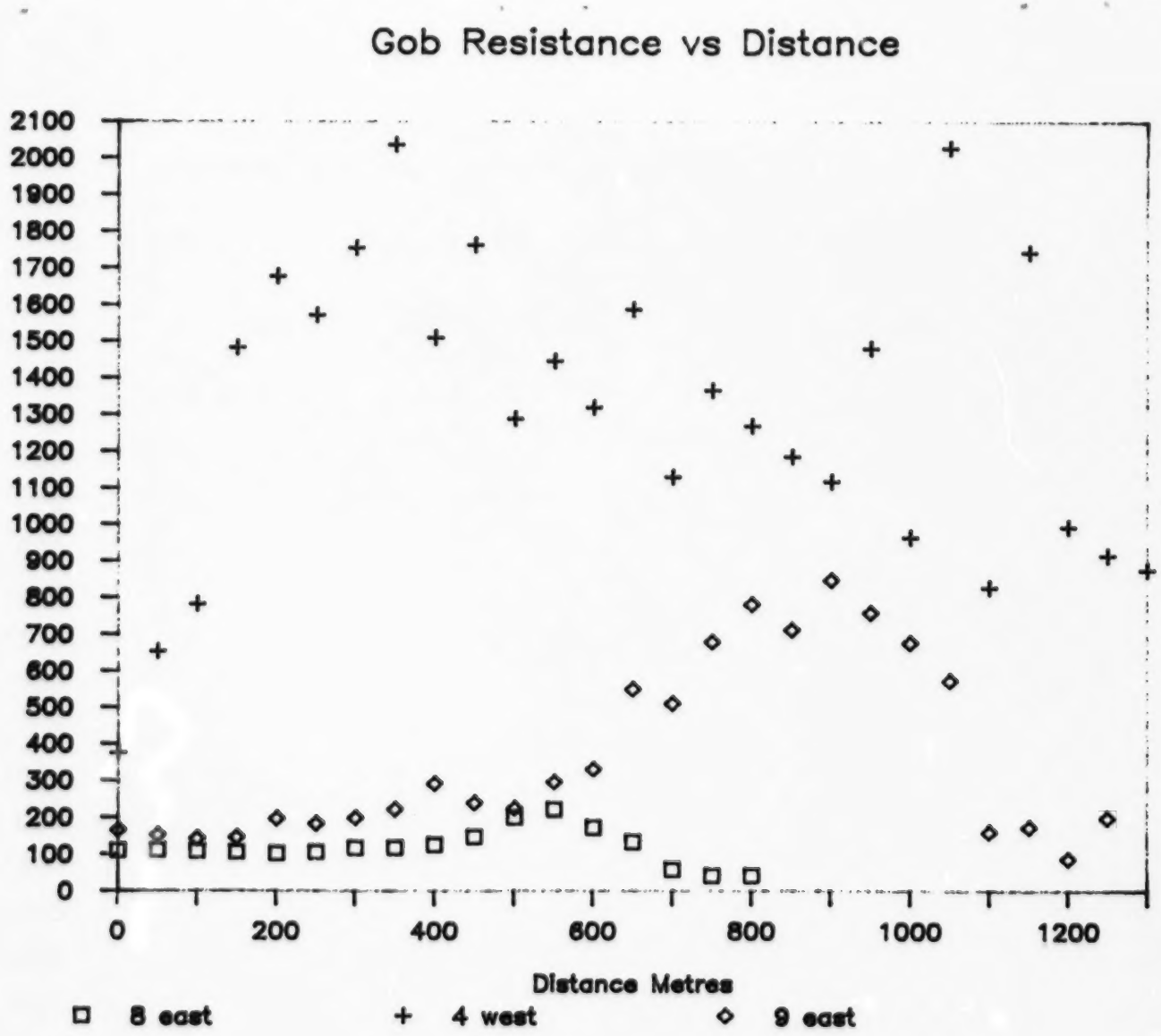

Figure 4 - Comparison of gob resistances assuming laminer flow (n = 1.2)

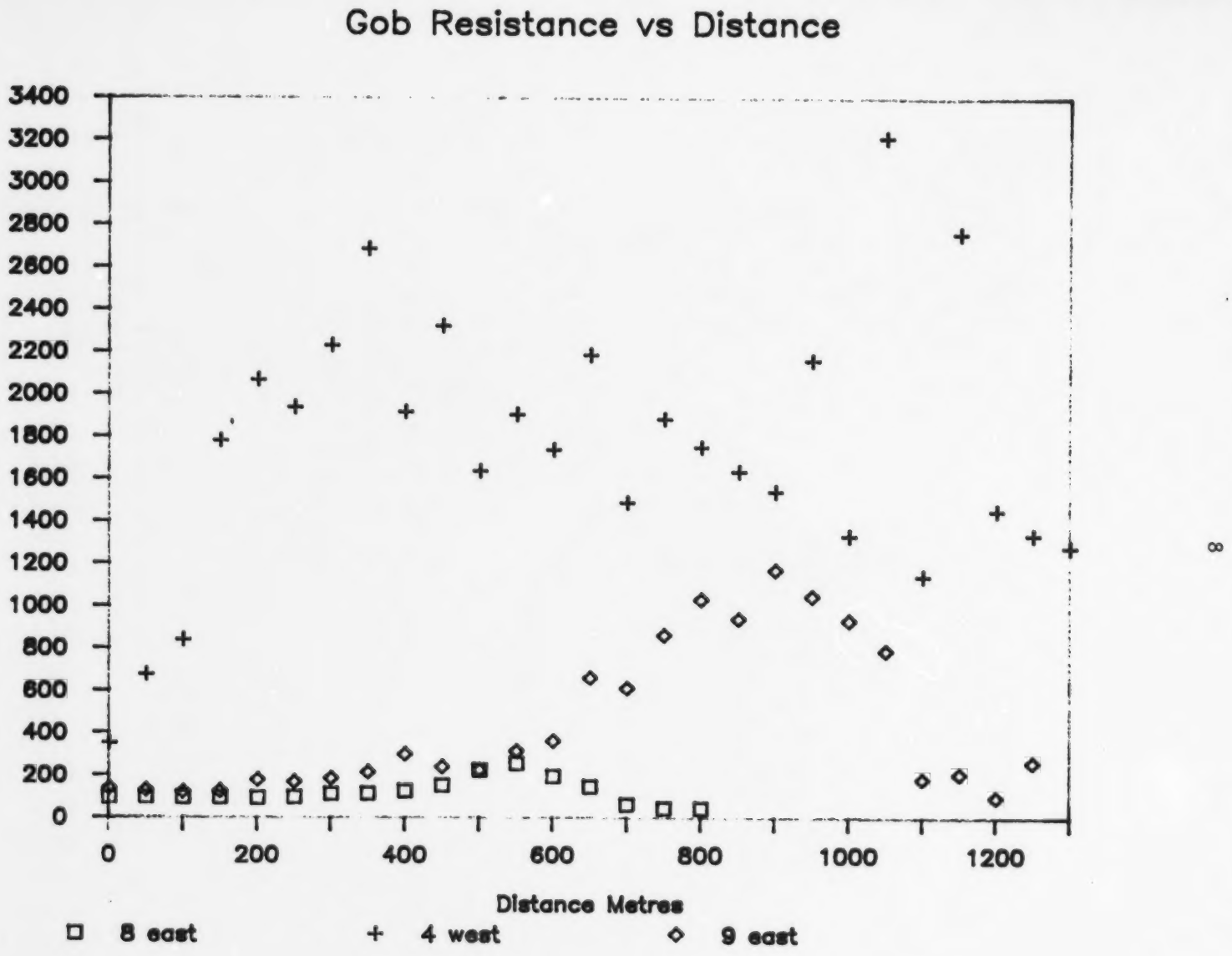

Figure 5 - Comparison of gob resistances for mixed flow (n = 1.4)

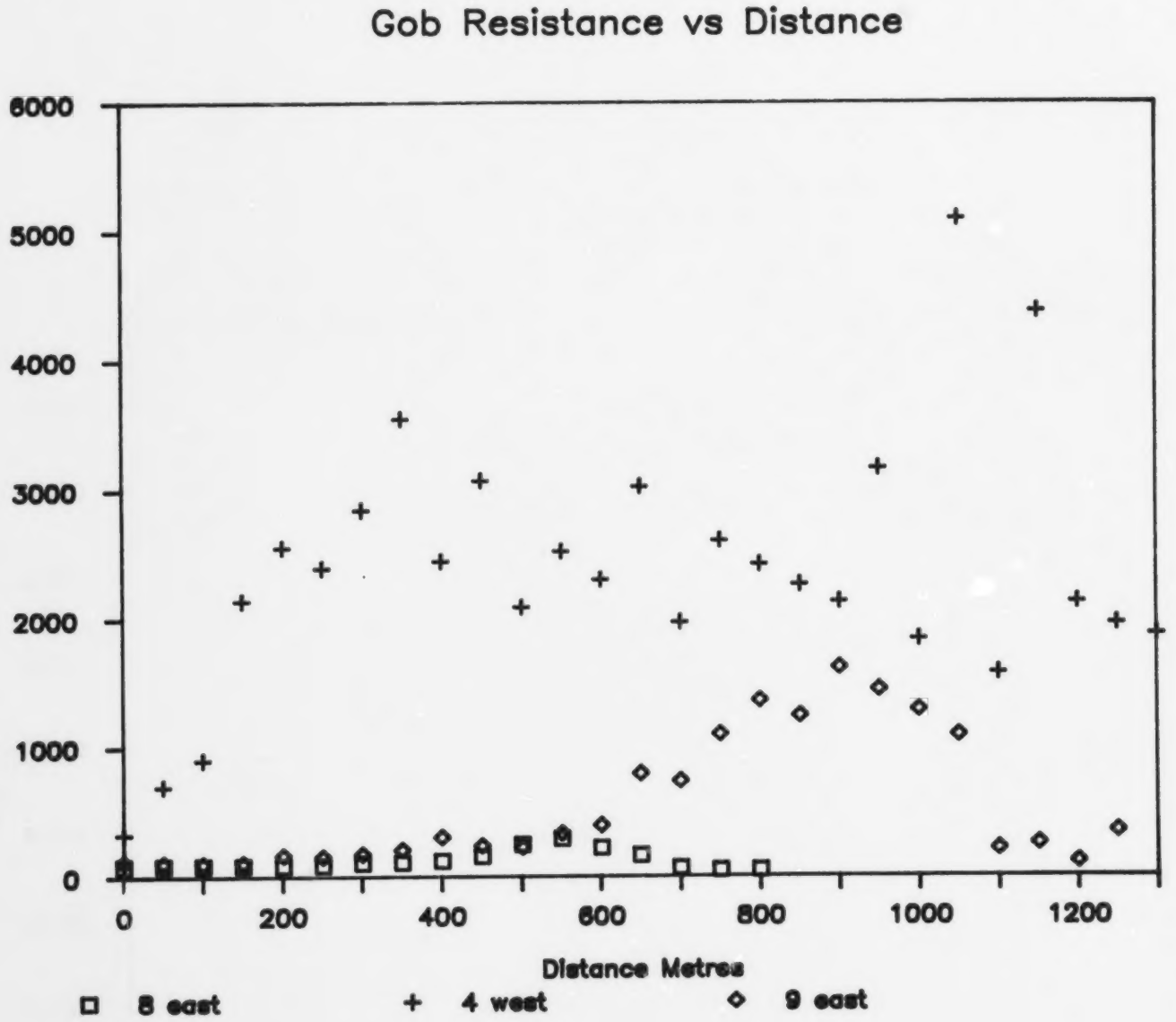

Figure 6 - Comparison of gob resistances for mixed flow (n = 1.6)

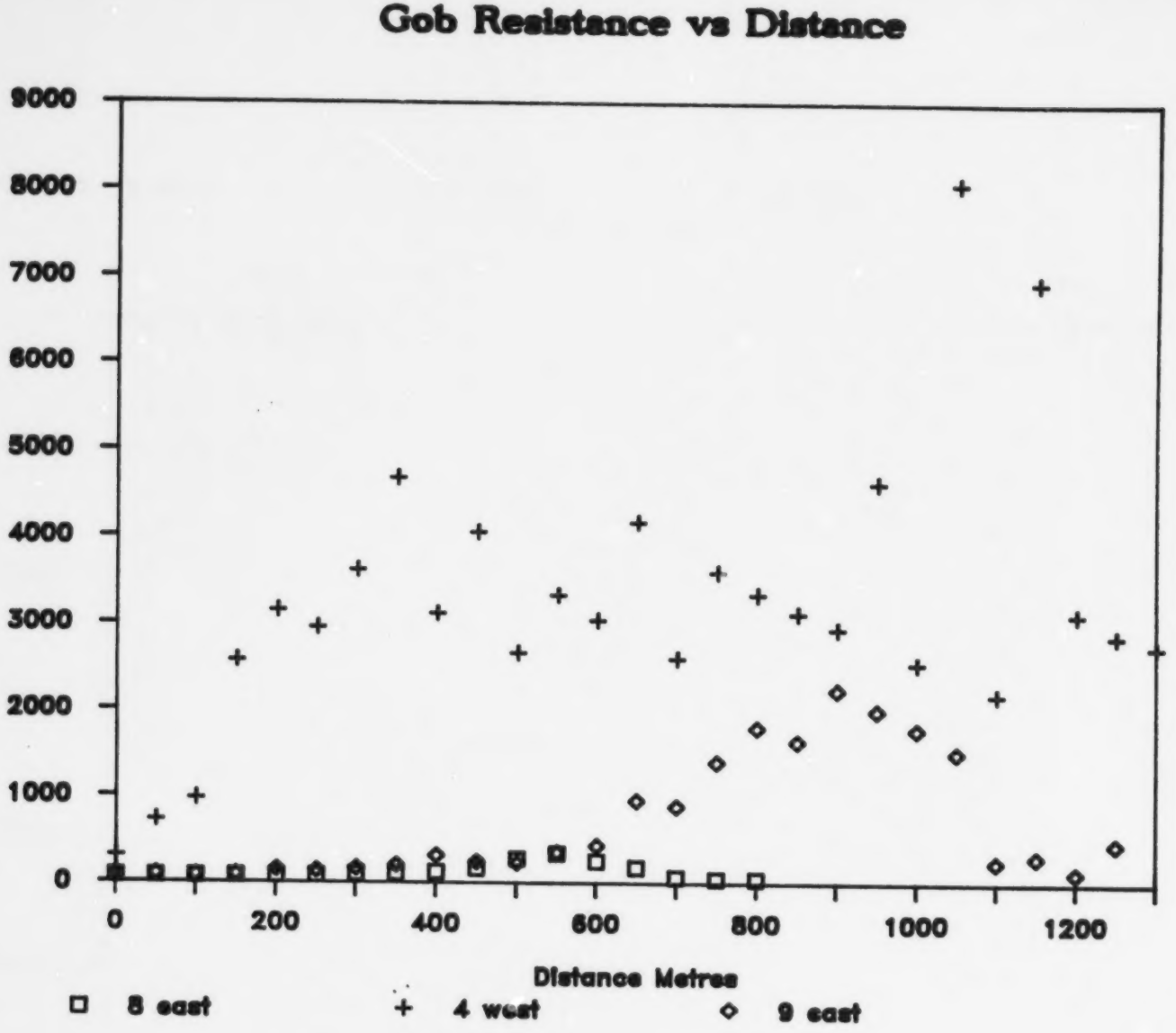

Figure 7 - Comparison of gob resistances for mixed flow (n = 1.8)

occurs between 600 m and 800 m into the wall face. This corresponds with the beginning of the monolithic packing at 640 m in. By 900 m in the gob corridor resistance values stabilise to an average value of approximately 1900 $Ns^2.m^{-8}$. This is several times higher than the resistance of the conventionally packed length of gob from the face startline to 640 m in. The average gob corridor resistance along this section is approximately 250 $Ns^2.m^{-8}$. The drop in the resistance values from 1000 m to the face occurs due to the air leakage from the face and is not truely representative of the state of the packing and gob consolidation.

GOB RESISTANCES FOR DIFFERING FLOW REGIMES

Due to the uncertainty of the flow regimes in the gob area a back analysis of data from the most recent surveys conducted on 9 East, 8 East and 4 West was undertaken. Figures 3 through 7 show the calculated gob corridor resistances calculated for each longwall assuming five different values for n in Atkinson's equation:

$$P = RQ^n \qquad \text{Eq 1}$$

where P is the differential pressure across the gob (Pa)
Q is the airflow through the gob corridor ($m^3.s^{-1}$)
R is the resistance of the gob corridor ($Ns^2.m^{-8}$)
and n is the indices which describes the type of flow in the gob corridor (e.g. n = 2 for turbulent flow and n = 1.2 for laminar flow)

The graphs show calculated values of resistance assuming completely turbulent flow (n = 2) to fully laminar flow (n = 1.2) in increments of 0.2.

Although the magnitude of the resistances change considerably (from a maximum value of 8000 $Ns^2.m^{-8}$ for turbulent to a maximum of 2050 $Ns^2.m^{-8}$ for laminar) the relative shapes of the curves remain virtually unchanged. The most noticeable features of the graphs are:

- Resistances on the 4 West longwall are generally higher than 9 East and 8 East.
- The resistance values for the conventionally packed lengths of 8 East and 9 East are approximately the same.

- The monolithic packed section of 9 East has a gob resistance close to the average value of 4 West's gob.

COMPUTER SIMULATION OF 9 EAST LONGWALL

The gob corridor resistance values shown in Tables 1, 2 and 3 were used with the roadway and face resistances of 9 East to do computer simulations of the district airflows. The graphs shown in Figure 8 represent three airflow prediction exercises.

Curve 1 shows the airflow profile predicted on the basis of the information from the survey data and is therefore the same as the curve shown in Figure 3.

Curve 2 shows the leakage that would have been experienced if the return packs had remained unchanged and wooden packs had been used throughout the intake. For this scenario the total amount of gob leakage is almost the same as is presently being experienced, but its distribution along the length of the gob is different. The monolithic packing now in place is forcing more air to leak through the section supported by wooden chocks along the first 640 m. This is caused by the monolithic packing producing an increase in the resistance of the inbye section of the district. Air follows the path of least resistance namely, through the first 640 m section of gob. For the wooden pack the leakage is more evenly distributed along the gob's entire length.

Curve 3 shows the predicted profile for the district with monolithic packing along the entire length of the intake gateroad and the old style pack in the return. From this we can deduce the real potential gains that could be attained from using the monolithic packing. The computer simulation suggests that for the present face advance almost 64 percent of the fireseal air quantity would reach the face. With this reduction in leakage it should be possible to complete a 2600 m longwall without utilising cundy ventilation.

ADDITIONAL LOAD ON THE MINE VENTILATION SYSTEM

If an east side longwall was worked to its limit with conventional ventilation and monolithic packing along its intake an increased load would be placed on the ventilation system.

Table 1 - Gob corridor resistances in 9 East

9 East
Gob Resistance Calculations
for 2%

Distance meters	Delta L.O. sec.	Delta Physical	22	21.8	21.6	21.4	21.2
0	2.6	495	79.1	95..	114.0	137.1	164.8
50	2.4	420	75.1	89.6	106.7	127.1	151.4
100	2.4	405	70.0	83.8	99.8	118.9	141.6
150	2.2	375	77.5	90.7	106.2	124.3	145.6
200	1.8	345	134.8	148.0	162.6	178.7	196.3
250	1.6	320	126.2	138.6	152.3	167.3	183.8
300	1.4	298	152.0	162.6	173.9	186.0	199.0
350	1.2	278	193.1	200.2	207.7	215.4	223.4
400	0.9	255	318.5	311.9	305.4	299.0	292.8
450	1.0	240	240.0	240.0	240.0	240.0	240.0
500	1.0	225	225.0	225.0	225.0	225.0	225.0
550	0.7	210	372.3	352.8	332.8	314.1	296.6
600	0.6	198	468.6	429.9	394.5	361.9	332.0
650	0.4	180	1143.7	952.1	792.8	660.0	549.5
700	0.4	170	1062.5	884.6	736.5	613.1	510.5
750	0.3	160	1777.8	1397.3	1098.3	863.3	678.5
800	0.2	148	2368.0	1794.6	1360.1	1030.7	781.1
850	0.2	135	2160.0	1637.0	1240.6	940.2	712.5
900	0.2	123	1972.0	1493.7	1131.1	856.8	649.0
950	0.2	110	1760..	1332..	1009.0	764.0	578.5
1000	0.2	98	2450.0	1775.7	1287.0	932.8	676.1
1050	0.2	83	2075.0	1505.9	1090.0	790.0	572.6
1100	0.5	70	280.0	243.7	212.2	184.7	160.8
1150	0.4	55	762.8	701.8	651.3	209.2	174.2
1200	0.6	46	153.3	120.4	108.7	98.1	88.6
1250	0.2	38	608.0	480.8	349.2	264.6	200.6

Table 2 - Gob corridor resistances in 4 West

4 West
Gob Resistance Calculations
for Q^x

dist meters	delta in.w.g./sec	delta Pascals/	R2	R1.8	R1.6	R1.4	R1.2
0	1.40	561	1122.0	1008.7	888.9	760.8	625.1
50	0.85	508	744.6	720.8	687.8	643.5	583.8
100	0.70	510	1040.8	969.2	902.4	840.0	782.4
150	0.40	494	3087.5	2870.5	2140.1	1781.7	1483.4
200	0.35	478	3585.7	3149.5	2552.0	2089.7	1677.7
250	0.35	446	3640.5	2951.3	2392.4	1939.3	1572.0
300	0.30	414	4600.0	3615.6	2841.9	2233.7	1755.7
350	0.25	386	6176.0	4680.5	3547.2	2688.3	2037.3
400	0.30	358	3955.6	3109.1	2443.7	1920.8	1509.7
450	0.25	334	5344.0	4050.0	3069.3	2326.1	1762.9
500	0.30	304	3377.3	2654.9	2086.5	1640.2	1289.2
550	0.25	274	4384.0	3322.4	2517.9	1908.2	1446.2
600	0.25	250	4000.0	3031.4	2297.4	1741.1	1319.5
650	0.20	230	5750.0	4167.5	3020.5	2189.2	1586.7
700	0.25	214	3424.0	2594.9	1966.5	1490.4	1129.5
750	0.20	198	4950.0	3587.7	2600.3	1884.6	1365.9
800	0.20	184	4600.0	3334.0	2416.4	1751.4	1269.4
850	0.20	172	4300.0	3116.3	2258.8	1637.1	1186.6
900	0.20	162	4050.0	2935.4	2127.5	1542.0	1117.6
950	0.15	152	5733.3	4822.5	3493.0	2534.3	1836.7
1000	0.20	140	3500.0	2536.7	1838.5	1332.6	965.8
1050	0.10	128	12800.0	9276.3	5095.8	3218.2	2028.7
1100	0.20	120	3000.0	2174.3	1575.9	1142.2	827.8
1150	0.10	110	11000.0	6940.5	4379.2	2763.1	1743.4
1200	0.15	102	4533.3	3102.1	2122.5	1452.4	993.8
1250	0.15	94	4177.8	2858.7	1956.1	1338.4	915.8
1300	0.15	90	4000.0	2737.0	1872.8	1281.5	876.9

Table 3 - Gob corridor resistances in 8 East

8 East
Gob Resistance Calculations
for 1

Dist	Delta Inc. sec	Delta Pascals	Res.01	Res.02	Res.03	Res.04	Res.05
0.00	2.15	276.4	59.3	59.7	81.2	94.3	110.3
50.00	2.00	254.9	50.2	72.9	87.3	98.2	110.5
100.00	1.90	224..	54.3	72..	80.3	95.3	108.3
150.00	1.80	214.1	56..	74.3	80.3	94..	105.3
200.00	1.70	194.2	57.1	74.7	83..	92.4	102.7
250.00	1.55	179.3	74.3	81.3	88.9	97.1	106.9
300.00	1.50	161.3	95.3	100.9	106.4	112.1	118.1
350.00	1.40	146.9	102..	105.3	109.7	113.3	118..
400.00	1.05	134.3	122.1	120.1	124.4	125.3	126.3
450.00	0.85	122..	138.9	130.3	133.2	133.2	134.7
500.00	0.60	109.3	204.7	274.3	245..	224.0	202.2
550.00	0.80	97.1	358.4	338.1	294.1	253.7	222.1
600.00	0.85	84.7	379.9	345.1	12..0	255.3	223.3
650.00	0.80	72.2	399.3	351..	312.3	147.3	133.3
700.00	0.80	44.3	70.0	67..	64.0	61.3	58.3
750.00	0.80	32.4	50.3	48.4	46.3	44.2	42.3
800.00	0.80	32.4	50.3	48.4	46.3	44.2	42.3

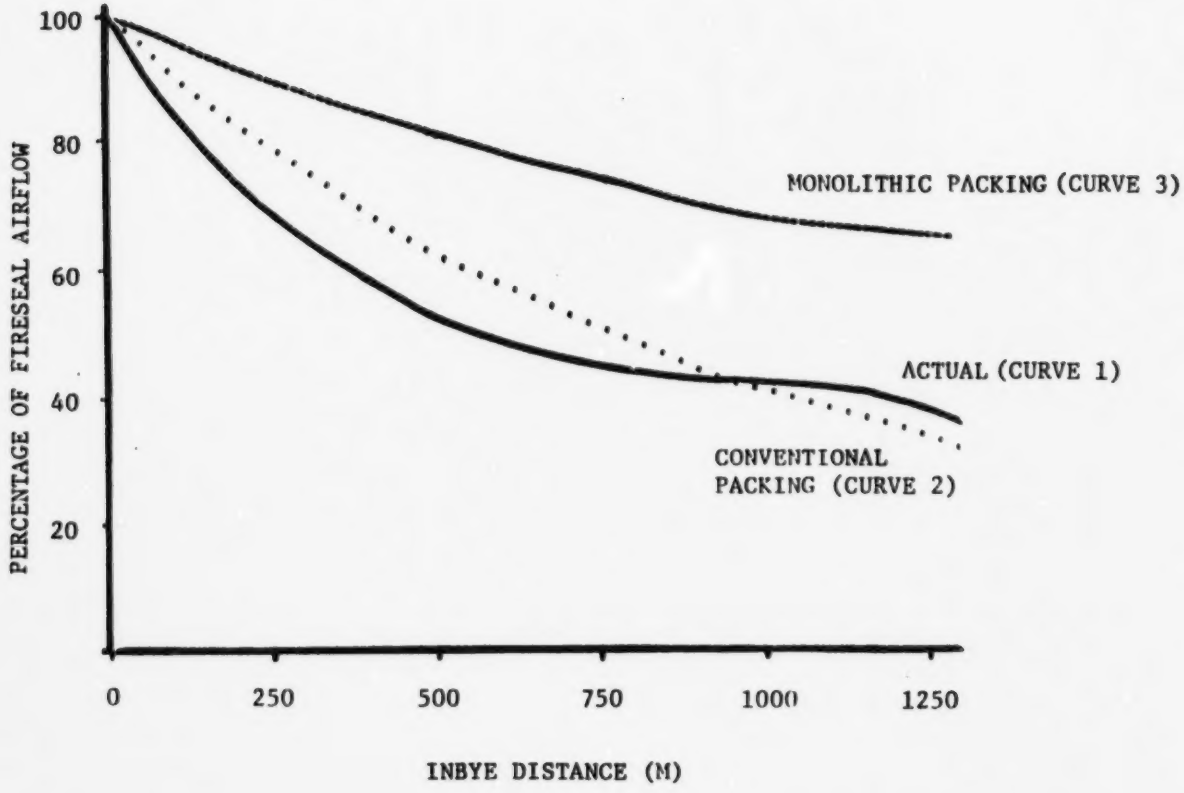

Figure 8 - Measured and predicted airflow profiles for 9 East

Presently, the east side walls place the maximum load on the ventilation system just prior to a cundy being connected to a longwall. At this time, more than 50 $m^3.s^{-1}$ (100,000 cfm) of air will be entering the district with a differential pressure across the ends of 0.65 KPa (2.5" wg). From network simulations it has been calculated that to get 20 $m^3.s^{-1}$ (40,000 cfm) to the face of a 2600 m long east side longwall, a ventilation pressure of between 1.25 and 1.5 KPa (5 to 6" wg) would be required across the outbye ends of the longwall.

This additional load may not be attainable with the existing main mine ventilation system at Lingan Colliery.

CONCLUSIONS

The monolithic packing used in 9 East longwall has produced a significant increase in the gob resistance and hence created a localised reduction in the air leakage. The benefit of this reduction was somewhat wasted due to the unsealed section of gob from the face startline to 640 m inbye.

Computer predictions show that monolithic packing of this standard would allow a 2600 m longwall to be mined on the east side of Lingan Colliery without utilising any other methods of leakage control.

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